SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
SURFACE PREPARATION AND COATINGS
DESIGN/PRODUCTION INTEGRATION
HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

September 1985
NSRP 0226

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

1985 Ship Production Symposium
Volume I
Paper No. 19:
Making the Right Connection - Piping Systems, Past, Present, and Future

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
SEP 1985	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
The National Shipbuilding Research Program 1985 Ship Production Symposium Volume 1 Paper No. 19: Making the Right Connection - Piping Systems, Past, Present, and Future	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center CD Code 2230-Design Integration Tools Building 192 Room 128 9500 MacArthur Bldg Bethesda, MD 20817-5700**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**20**	

DISCLAIMER

These reports were prepared as an account of government-sponsored work. Neither the United States, nor the United States Navy, nor any person acting on behalf of the United States Navy (A) makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness or usefulness of the information contained in this report/ manual, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or (B) assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in the report. As used in the above, “Persons acting on behalf of the United States Navy” includes any employee, contractor, or subcontractor to the contractor of the United States Navy to the extent that such employee, contractor, or subcontractor to the contractor prepares, handles, or distributes, or provides access to any information pursuant to his employment or contract or subcontract to the contractor with the United States Navy. ANY POSSIBLE IMPLIED WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR PURPOSE ARE SPECIFICALLY DISCLAIMED.

"MAKING THE RIGHT CONNECTION"

Piping Systems, Past, Present and Future

By

DAVID C. KELLY

"PYPLOK® PROGRAM MANAGER

Deutsch

Metal Components

Abstract

A fundamental concern of members of the shipbuilding community is the escalating cost of repairing and fabricating piping systems. These shipbuilders are searching for ways to reduce installation costs and to improve the quality and timeliness of shipyard output.

The primary cost in attaching segments of a piping system is directly related to installation man-hours for welding or brazing, flushing, hydro-static testing, quality assurance and potential re-work. The more labor intensive the piping installation, the greater the need for an alternative method.

New technologies have provided more cost effective methods for permanently joining piping. One viable alternative is the Swage Marine Fitting.

Swage Marine Fittings (SMF) are mechanically applied connections that significantly reduce installation man-hours by eliminating hot-work and conventional N.D.T.

This paper will discuss the history of welding and brazing, the development of mechanically applied pipe connections and the potential impact that this technology will have on the future of piping fabrication and repair.

The topic of this presentation, dealing with mechanically applied Swage Marine Fittings, lends itself very well to the theme of the 1985 NSRP Symposium. .."Moving Ahead With The Implementation Of Advanced Technology."

Mechanically applied pipe connections represent a new generation pipe joining technique that was developed to reduce the ever-increasing costs associated with marine piping fabrication and repair.

When utilizing conventional weld and sil-braze installation methods, the installation requirements are often costly and time consuming. There is a high skill level required for welders installing high pressure piping systems. The maintenance of this skill is accomplished through systematic training, qualification and certification. The quality and integrity of conventionally installed piping systems are mostly dependent on the skill level of the installer.

Conventional Piping Installations

The means of attaching sections of piping and the installation of components within a piping system will vary with systems, media, pressure, temperature and pipe material.

The primary pipe joining methods commonplace in the marine industry are welding, silver brazing and threading.

Welding

Welding is the most common means of interconnecting ferrous piping. Arc welding has historically been a major problem area in marine pipe production. There are a number of variables that must be closely controlled to guarantee joint efficiency.

Pipe welding can become a very uncomfortable process in many shipboard environments which in turn>effects overall productivity.

The fact that the welding process elevates the immediate weld zone to liquid temperatures causes additional problems.

The metallurgical properties of the piping and fitting material are disturbed during the installation. In addition to the chemical and physical changes that occur, a heat affected zone is established, wherein, depending on material, metallurgical and physical properties such as localized annealing are highly probable. Other factors such as potential weld inclusions and porosity must be considered.

After the welded installation is completed there is always a probability of joint rework. The percentage of rejected pipe welds will vary with each shipyard, but weld reject rates are always a consideration with some yards documenting an unbelievable amount.

Of course the installed system is then subjected to non-destructive testing, hydrostatic testing and flushing. Welded installations typically involve high labor costs and comparatively low material costs.

Brazing

Commonly used to attach cuprous piping and components is also a labor intensive technique that generally requires highly skilled technicians.

There are several factors that must be considered beyond the actual mechanics of the sil-braze installation. When silver brazing “in-place” on-board ships, special precautions must be taken to protect the surrounding area. Ventillation ducting, wire-ways, non-structual bulkheads, lighting and equipment interferences must be protected from the open flame of the brazing torch. Avoiding heat-related damage to adjacent components is an additional responsibility of the pipe fabrication crew.

The post-installation cleanliness and flushing requirements for silver brazed piping are also very time consuming and expensive. Hot flushing to eliminate contaminants and flux residue is a major cost factor in cuprous piping installations.

Again the skill level of the installer is a major influence on the quality and integrity of the completed system.

Threaded Systems

Threaded systems are not as commonplace nor as labor intensive as the two methods previously discussed. They are, though, very troublesome due to the significant number of potential leak paths created through the threading process.

This potential for systems leakage and the requirements for subsequent corrective action make the threaded piping system potentially labor intensive.

These three conventional pipe connecting methods have been recognized for years as industry standards.

Reliable cost saving alternatives have been virtually nonexistent -- "until recently."

Swage Marine Fittings

There are now several recognized alternatives to the more conventional pipe joining techniques:

- The Swage Marine Fitting, the generic reference used by Naval Sea Systems Command for PYPLOC® fittings manufactured by Deutsch Metal Components of Los Angeles, California, and

-- The Heat Recoverable Coupling, the NAVSEA reference for Cryofit fittings manufactured by Raychem Corporation of Menlo Park, California.

Both technologies have been topics of technical papers presented at either ASNE or SNAME symposiums.

The most recent presentation on PYPLOK® Swage Marine Fittings was given by Commander Dennis Mahoney at the ASNE Shipbuilding and Repair Symposium in September of 1981.

The information presented in CDR Mahoney's paper was based on PYPLOK® Swage Marine Fitting prototype development and potential cost savings. At that time there were no maritime approvals for the use of Swage Marine Fittings nor were there any studies available of actual PYPLOK® installations.

This paper will discuss actual case histories and Method Improvement Studies compiled by various U. S. Naval activities demonstrating a tremendous cost savings per each installed joint.

Background of SMF (Swage Marine Fitting)

About (15) fifteen years ago the Deutsch Company developed a technology that came to be known as the "Radial Swage Concept." Whereby the outside diameter of a specially designed fitting is mechanically reduced, brought into contact with the pipe or tube, creating a pre-determined deformation in that pipe or tube thereby providing an intimate mechanical seal.

This technology was first introduced to the aerospace industry-in the form of an aircraft tube connector trade named Permaswage®.

McDonnell Douglas was the first to use the Radial Swage Aircraft Fitting in 1970.

Since then, Permaswage® Radial Swage Fittings have been designed into virtually every aircraft manufactured in the free world; including the B-1 bomber, the Cruise Missle and the Space Shuttle.

Permaswage® fittings are standard repair items on all military aircraft with state-of-the-art radial swage tooling covered by a Mil-Spec (Mil-K-87957).

In March of 1978, Deutsch Metal Components contacted Naval Sea Systems Command with a development proposal for a marine version of the Permaswage® aircraft tube connector.

NAVSEA was very receptive to the possibility of marine applications of this very successful Radial Swaged Aircraft Fitting. After extensive review of the Deutsch proposal, NAVSEA decided to proceed with the PYPLOK® project.

In conjunction with David Taylor Naval Research and Development Center (DTNSRDC Annapolis, MD), NAVSEA developed an extremely demanding test schedule for PYPLOK® Swage Marine Fittings that included the following tests:

Hydraulic System Qualification (3,000 psig)

Impulse test - 1,000,000 cycles at 70 CPM, 3750 psig peak pressure.

- Flexure test - 80,000 cycles at 3750 psig static pressure and a 60 KSI bending stress for CRES fittings, 44 KSI for CNA fittings at a rate of between 7 and 35 CPM.

- MIL-S-167 vibration test - while pressurized at 3.,000 psig, at frequencies between 4 and 50 Hz, with a 2-hour period at either resonant frequency or 50 Hz if no resonance was found.

- MIL-S-901C shock test (at 3,000 psig).

- High temperature aging test 275° ±5°F (132 -137°C) for 1 week.

  Burst test (five times pressure rating of pipe minimum).

- Compatibility testing - on thin wall CRES (.065 wall, Sch. 5) and 90/10 CNA (.072 wall, CL 200).

- Tensile pull-out - tensile strength of fitting sample must meet or exceed the minimum yield strength of the pipe material.

Pneumatic System Qualifications (6,000 psig)

Combined impulse/flexure - 80,000 cycles, pressures from O to 5,625 psig, bending stresses from O to 60 KS I for CRES, and O to 44 KS I for CNA. The rate of cycling was six to eight per minute. At the completion of this test, a proof test at 9,000 psig was performed for 5 minutes. At intervals of approximately 10,000 cycles the procedure was interrupted, and with the peak pressure, and bending stress still applied the samples were subjected to a cold soak at -100°F (-73°C) for 1 hour using solid CO_2. The test medium was MIL-H-5606 hydraulic oil.

- Vibration test - similar to that indicated in (a) above, sample pressurized to 6,000 psig.

  MIL-S-901C shock test (at 6,000 psig).

High temperature aging test 450°F ±5°F (232°C) for 1 week.

- Burst testing (24,000 psig, minimum).

- Compatibility testing of the high pressure rated fitting on thin-wall pipe/tubing.

These tests were conducted on the following pipe materials:

- CRES (Corrosion Resistant Steel)
- Carbon Steel
- 70/30 CNA
- 90/10 CNA
- Copper

All pipe wall thickness were tested in ferrous piping to Schedule 160 and in cuprous pipe to Class 6000.

This exhaustive testing was conducted over a (4) four year period and independently funded by Deutsch Metal Components.

The satisfactory completion of all required testing and the positive results of numerous trial applications were acknowledged by Naval Sea Systems Command in a blanket approval letter issued in January 1985 approving the Navy-wide use of PYPLOK® Swage Marine Fittings.

This NAVSEA approval letter states that PYPLOK® Swage Marine Fittings are approved for use on systems with an operating temperature of -60°F to + 400°F. Fittings manufactured from 316L CRES are approved for use Up to 1-1/2″ NPS (1.900″) on piping materials of carbon steel and stainless steel in all wall thicknesses up to Schedule 160.

Fittings manufactured from 70/30 Copper Nickel (MIL-C-15726) are approved for use on piping materials of 70/30 CUNI, 90/10 CUNI and copper in wall thicknesses up to Class 6000.

As of this writing, PYPLOK® Swage Marine Fittings are not approved by NAVSEA 08 for use on ships or submarines under the cognizance of the U. S. Navy Nuclear Power Directorate.

Case Histories

PYPLOK® fittings are, however, approved for use in systems onboard non-nuclear surface ships.

Several Method Improvement Studies conducted by the U. S. Navy have demonstrated that through the use of Swage Marine Fittings, shipyards can realize cost savings upwards of 70% on P-1 and P-2 ferrous piping systems and upward of 50% on P-3A and P-3B cuprous piping systems.

A study conducted by production Engineering, Code 383, at Puget Sound Naval Shipyard (PSNS) of a fitting installation on the USS Constellation reflected a cost savings of $64K on 314 installed fittings of various configurations. This breaks down to a very impressive savings of $203.00 per installed fitting. This study did not include any savings in systems flushing.

A similar study was conducted by production Engineering Code 383 at Charleston Naval Shipyard (CNSY) .

Shop 56 installed (130) PYPLOK® Swage Marine Fittings on the CO_2 activation side of the Halon 130-1 System onboard the USS Mahan (DDG-42) thereby eliminating (312) P-1 weld joints. The total documented savings was $32,879.32 or a savings of $252.00 per installed fitting.

These figures we compiled by using both standard Navy stabilized material and labor rates.

One other Method Improvement Study was documented by the Shore Intermediate Maintenance Activity, Norfolk, Virginia. This was a cost savings evaluation by SIMA, Norfolk of a repair to the ASROC loader hydraulics system (JSN WS01-0487) onboard the USS Harry E. Yarnell.

A small quantity of PYPLOK® Swage Marine Fittings were used to effect the repair and the cost savings was documented to be $403.00 per installed fitting.

Benefits of Swage Marine Fittings

How is it possible to demonstrate such a dramatic cost savings through the use of PYPLOK® Swage Marine Fittings?

The theory behind the development of PYPLOK® was to controllably increase the material cost of the fittings required for an installation and dramatically reduce the associated man-hour requirements. The more labor intensive the piping project, the greater the reduction in direct and indirect labor cost.

If Swage Marine Fittings are given the proper considerations during various stages of assembly and fabrication, the piping can all be pre-cleaned and pre-pickeled. Post installation flushing requirements can be minimized or excluded; non-destructive testing is completely eliminated.

Due to the absence of any hot-work during the PYPLOK® installation, there is no need for a fire watch or any gas freeing.

Fittings can be installed in repair applications without systems drainage or precautionary flushing. Fittings can even be installed in various explosive atmospheres.

The PYPLOK® system is a deliberate system, wherein the installer can piece a system together and verify dimensions and alignment prior to swaging. The installed fittings are one piece, permanent and tamper-proof after installation.

PYPLOK® fittings are manufactured in NPS, OD and metric sizes up to 2" NPS. They are available in materials of 70/30 CUNI, 316L CRES and Carbon Steel. Although the U. S. Navy has only approved the use of standard configurations, they are commercially available in various pressure rated flanges, reducers and adapters.

This technology lends itself to the development of a never ending variety of configurations designed to satisfy the needs of the marine piping industry.

The international market place has been most receptive to this technology. PYPLOK® Swage Marine Fittings are presently being used by the French Navy for the repair of non-nuclear systems on nuclear submarines.

The British are using PYPLOK® fittings for both repair and new construction in marine and industrial projects.

In Japan, IHI has developed a design specification for PYPLOK® applications on numerous marine projects.

The implementation of this technology is a worldwide interest that affects marine and industrial projects on an international scale.

Specifications and Approvals

In addition to the NAVSEA approval discussed earlier, PYPLOK® fittings have been approved by virtually every maritime approval agency in the world including Lloyd's, NKK? DNV and the U. S. Coast Guard. American Bureau of Shipping has included PYPLOK® Swage Marine Fittings under their Equipment Type Approval Program..

A Military Performance Specification on Swage Marine Fittings (SMF) has recently been submitted to Naval Sea Systems Command for review.

The ASTM F-25 Committee has a task group F-25.09.13 responsible for developing a performance specification on PYPLOK® (referenced as "Mechanically Applied Fittings") . This document is presently out on preliminary ballot to the ASTM piping subcommittee.

PYPLOK® fittings have been specifically called out as an option in Section 505 of the Arleigh Burke DDG-51 piping specifications.

In the petro-chemical industry, PYPLOK® technology has been the subject of industry specifications developed by Exxon International, Dow Chemical, Dupont and others.

The Future

The future of this technology is unlimited. With an approved MIL-SPEC and ASTM-SPEC, PYPLOK® type fittings will be included in both MIL-STD-438 and MIL-STD-777. This development will provide marine design engineers with the flexibility to specify PYPLOK® Swage Marine Fittings on design drawings if the applications are considered to be cost effective.

Given the amazing reliability of installed PYPLOK® fittings and the proven cost effectiveness in service, these Swage Marine Fittings are destined to revolutionize the pipe connecting industry.

A shipyard is truly “moving ahead” through implementation of this advanced technology.

REFERENCES

1. "Marine Applications of Externally Swaged Pipe Fittings" by CDR Dennis Mahoney presented to the ASNE Shipbuilding and Repair Symposium September 18, 1981.

2. Method Improvement Study by Puget Sound Naval Shipyard Code 383 entitled "Comparison of 3000 PSI CRES Swage Marine Fittings (SMF) and Conventional Weld Fittings" FSR: 0383-8091 dated December 2, 1983.

3. Method Improvement Study by Charleston Naval Shipyard Code 383 entitled "Swage Marine Fittings (PYPLOK®)" SER: 380-1432 dated June 5, 1984.

4. Cost Savings Analysis by Shore Intermediate Maintenance Activity Norfolk Naval Station entitled "PYPLOK® System on USS Yarnell" dated May 9, 1985.